

Message Text

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UNCLAS SECTION 1 OF 3 LISBON 3362

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SUBJ: GEOTHERMAL ENERGY PROJECT - CCMS

SUMMARY: A US TEAM OF TWO, REPRESENTING THE USGS AND AEC, VISITED GREECE SEPT. 5-8 TO REVIEW GEOTHERMAL ENERGY DEVELOPMENTS AND TO LOOK INTO POSSIBLE CCMS PROJECTS IN THAT FIELD. THE MAIN PROMOTER OF GEOTHERMAL ENERGY IN GREECE IS MR. PANAYIOTIS E. GOUNARIS, VICE GOVERNOR OF THE PUBLIC POWER CORPORATION (PPC), A GOVERNMENT-OWNED MONOPOLY. EXPLORATION HAS BEEN CONDUCTED FOR 1 1/2 YEARS, UNCLASSIFIED

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MAINLY BY FOREIGN EXPERTS IN GEOLOGY, GEOCHEMISTRY, AND

GEOPHYSICS. A SMALL STAFF OF GREEK NATIONALS IS DOING GEOLOGIC MAPPING AND CHEMICAL ANALYSES OF WATERS. PROF. GIORGIO MARINELLI, OF THE ISTITUTO DI MINEROLOGIA E PETROGRAFIA DELL 'UNIVERSITA DI PISA (IMPP), IS DIRECTING ALL OF THE SCIENTIFIC AND PRACTICAL ASPECTS OF THE EXPLORATIONS PROGRAM.

GEOLOGIC MAPPING, GEOCHEMISTRY OF HOT SPRING WATERS, ELECTRICAL RESISTIVITY SURVEYS, AND THERMAL GRADIENT MEASUREMENTS IN SHALLOW (50 TO 80M) HOLES ARE THE MAIN EXPLORATION TECHNIQUES EMPLOYED. TO DATE ABOUT \$85,000 HAS BEEN SPENT ON EXPLORATION. MOST OF THE DETAILED EFFORT HAS BEEN ON THE ISLAND OF MILOS, CONSIDERED THE MOST FAVORABLE LOCALITY FOR FINDING AND DEVELOPING GEOTHERMAL ENERGY. STEAM WAS FOUND THERE IN ONE SHALLOW WELL AT A DEPTH OF 35 M. THREE WELLS 700 TO 1000 M DEEP WILL BE DRILLED THERE STARTING EARLY NEXT YEAR. THE FRENCH SOCIETY "EURAFREP" WILL OFFER TECHNICAL ADVICE FOR THE DEEP DRILLING OPERATION. FUTURE FUNDING FOR GEOTHERMAL ENERGY IN GREECE MAY DEPEND ON FAVORABLE RESULTS OF THAT DRILLING. OTHER AREAS SELECTED FOR ADDITIONAL EXPLORATIVE WORK ARE, IN ORDER OF DECREASING INTEREST, NYSEOS, LESBOS, METHANA, SOUSAKI, THERMOPYLAE, AND NORTHERN EUBOEIA. IN GENERAL, HOT SPRINGS LOCATED ON AND NEAR THE GREEK MAINLAND HAVE TEMPERATURES BELOW 50 DEGREES C AND THEIR CHEMICAL COMPOSITIONS SUGGEST LOW SUBSURFACE TEMPERATURES. THEY TEND TO BE LOCATED ALONG REGIONAL E-W AND N-S FAULTS. IN CONTRAST THE HOT SPRINGS ON THE AEGEAN VOLCANIC ISLANDS COMMONLY HAVE HIGHER TEMPERATURES AND THEIR CHEMICAL COMPOSITIONS SUGGEST EVEN HIGHER SUBSURFACE TEMPERATURES.

THE BEST PROSPECTS FOR DEVELOPING GEOTHERMAL ENERGY FOR PRODUCTION OF ELECTRICITY APPEAR TO BE ON ISLANDS IN THE AEGEAN SEA. IT IS PROBABLE THAT ELECTRICITY WOULD BE USED FOR NEW INDUSTRIES THAT WOULD BE MOVED TO THE POWER SOURCE.

GREECE IS INTERESTED IN THE RESULTS OF A CCMS PROJECT ON GEOTHERMAL ENERGY, BUT CANNOT CONTRIBUTE AT THIS TIME BECAUSE OF LIMITED EXPERIENCE WITH THE SUBJECT.

END SUMMARY

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1. A US TEAM OF TWO (R. FOURNIER OF US GEOLOGICAL SURVEY AND A. LUNDBERG OF LAWRENCE LIVERMORE LABORATORY REPRESENTING US AEC) VISITED GREECE SEPT. 5-8 TO REVIEW GEOTHERMAL ENERGY DEVELOPMENTS AND TO LOOK INTO POSSIBLE CCMS PROJECTS IN THAT FIELD. THE HOST FOR THE MEETINGS WAS MR. P.E. GOUNARIS, A VICE-GOVERNOR OF PUBLIC POWER CORP. (PPC), A GOVERNMENT-OWNED MONOPOLY. MR. GOUNARIS WAS EXCEEDINGLY HELPFUL AND HOSPITABLE.

TWO FULL DAYS WERE SPENT ON FIELD TRIPS: (1) TO HOT SPRING AREAS NE OF ATHENS (THERMOPYLAE AND EDIPSOS), AND (2) TO THE ISLAND OF MILOS SE OF ATHENS. PROF. GIORGIO MARINELLI OF ISTITUTO DI MINEROLOGIA E PETROGRAFIA DELL'UNIVERSITA DI PISA (IMPP) WAS IN GREECE AT THE TIME AND SPENT ONE FULL DAY WITH THE GROUP, VISITING MILOS.

2. INTEREST IN GEOTHERMAL ENERGY IN GREECE IS FOR PRODUCTION OF ELECTRICITY. ACCORDING TO MR. GOUNARIS CONSUMPTION OF ELECTRICITY HAS BEEN GROWING AT 14 PER CENT PER YEAR FOR THE LAST 5 YEARS. CAPACITY HAS INCREASED FROM 1500 MW IN 1967 TO 3400 MW IN 1973. TOTAL PRODUCTION ALSO WENT UP ABOUT 150 PERCENT TO 13,700 MILLION KILOWATT-HOURS IN SAME TIME PERIOD, BUT HEAVY INDUSTRY USAGE HAS GONE UP ABOUT 250 PERCENT.

3. FROM 1967 TO 1973, 14 GENERATING UNITS WERE ADDED, AND 9 MORE WITH CAPACITY OF 1635 MW ARE IN VARIOUS STAGES OF CONSTRUCTION. THREE OF THE NEW UNITS WILL USE PEAT; SOME 44,000 ACRES WILL BE EXPLOITED FOR 300 MILLION TONS OF PEAT TO SUPPLY THE GENERATING PLANTS FOR 25 YEARS. APPROXIMATELY 4 BILLION TONS OF PEAT ARE KNOWN IN THAT AREA OF NORTHERN GREECE
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5. AT PRESENT, MR. GOUNARIS IS THE MAIN PROMOTER OF GEOTHERMAL ENERGY IN GREECE. APPROXIMATELY 1 1/2 YEARS AGO HE INITIATED A PROGRAM OF EXPLORATION FOR GEOTHERMAL ENERGY USING FOREIGN CONSULTANTS TO DIRECT THE EFFORT. PROF. MARINELLI IS NOW THE CHIEF CONSULTANT WHO IS IN CHARGE OF OVERALL EXPLORATION EFFORT. MARINELLI VISITS GREECE QUARTERLY FOR TEN DAYS EACH TRIP IN ORDER TO EXERCISE THAT DIRECTION.

6. MR. EDUARDO DOMENICO (FORMERLY WITH UNITED NATIONS AND NOW WITH A PRIVATE CONSULTING FIRM IN ITALY) INTERPRETED THE EARLY GEOCHEMICAL RESULTS. MR. DUPRAT, OF COMPAGNIE GENERAL DE GEOPHYSIQUE (CGG) HAS CONDUCTED UNCLASSIFIED UNCLASSIFIED

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AN ELECTRICAL RESISTIVITY SURVEY OF MILOS. PRESUMABLY MR. DUPRAT WILL DO OTHER RESISTIVITY WORK AS NEEDED. ON LESBOS, A SHALLOW-PROBING ELECTRICAL RESISTIVITY STUDY WAS PERFORMED BY TSVI MEIDAV (FORMERLY WITH THE UNIV. OF CALIFORNIA AT RIVERSIDE AND NOW WITH U.N.), AND SEVERAL 50 M THERMAL GRADIENT WELLS WERE COMPLETED UNDER GUIDANCE OF BUNDESANTALT FUR BODENFORSCHUNG OF MANNOVER. PROF. MARINELLI IS NOT PLEASED WITH THAT LESBOS WORK AND PARTICIPATION BY MEIDAV AND THE GERMAN GROUP HAS ENDED. FRENCH WORKERS FROM THE SOCIETY "EURAFREP," WILL OFFER TECHNICAL ADVICE DURING DEEPER DRILLING STAGE OF EXPLORATION AND DEVELOPMENT. A PRIVATE COMPANY NOT YET SELECTED WILL DO THE ACTUAL DEEP DRILLING.

7. A FEW GREEK NATIONALS WORK FULL OR PART TIME ON THE GEOTHERMAL PROGRAM. CHEMICAL ANALYSES OF SPRING AND WELL WATERS ARE BEING PERFORMED BY MISS PASTAMATAKI ARTEMIS (PART TIME) AT THE INSTITUTE OF GEOLOGY AND SUBSURFACE RESEARCH (IGSR) IN ATHENS. THE MAJOR PORTION OF GEOLOGIC MAPPING IS BEING DONE BY MR. MIKE FYTIKAS (FULL TIME) WHO IS ALSO WITH IGSR. MR. VASSILIOS PARASKOUDIS (PART TIME), A PRIVATE CONSULTING GEOLOGIST, ALSO PERFORMS GEOLOGIC MAPPING.

8. THERE IS AN ABUNDANCE OF HOT SPRING LOCALITIES IN GREECE. IN GENERAL DISTRIBUTION OF SPRINGS ON AND NEAR THE MAINLAND SEEMS TO BE CONTROLLED BY A SERIES OF NS AND EW REGIONAL FAULTS. THE CHEMICAL COMPOSITIONS OF THOSE WATERS SUGGEST RELATIVELY LOW TEMPERATURES (LESS THAN 100 DEGREES C) OF WATER-ROCK EQUILIBRATION AT DEPTH; THE WATERS ARE RICH IN CALCIUM BICARBONATE AND DO NOT DEPOSIT SILICA. IN CONTRAST, THE HOT SPRINGS AND

FUMARoles ON THE Aegean ISLANDS ARE ASSOCIATED WITH RELATIVELY RECENT VOLCANISM AND WATER COMPOSITIONS SUGGEST HIGH SUBSURFACE TEMPERATURES. SPRING WATERS TEND TO BE RICH IN CALCIUM CHLORIDE AND IRON CHLORIDE. SOME CHLORIDE-RICH WATERS HAVE PH VALUES OF 3. IT IS NOT KNOWN WHETHER THE LOW PH VALUES ARE DUE TO OXIDATION OF HYDROGEN SULFIDE AT THE WATER TABLE, OR WHETHER COMPARATIVELY ACID CONDITIONS EXIST AT DEPTH.

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9. PROF. MARINELLI CONSIDERS CERTAIN GEOLOGIC CONDITIONS ESSENTIAL FOR DEVELOPMENT OF AN EXPLOITABLE GEOTHERMAL SYSTEM. THESE INCLUDE: (A) ANOMALOUSLY HIGH HEAT FLOW, EITHER LOCAL OR REGIONAL; (B) PERMEABLE ROCK SITUATED ABOVE OR ADJACENT TO THE HEAT SOURCE, THAT ACTS AS A RESERVOIR FOR HOT WATER AND/OR STEAM, AND (C) AN IMPERMEABLE COVER OR CAP ROCK THAT EFFECTIVELY SEALS THE RESERVOIR AND PREVENTS RAPID DISPERSION OF HOT FLUIDS. THE COVER MAY BE COMPOSED OF ROCKS THAT INITIALLY HAD LOW PERMEABILITY OR MAY FORM THROUGH A PROCESS OF SELF-SEALING WHERE HOT WATER HAS REACTED WITH ROCK SO THAT THE ORIGINAL POROSITY AND PERMEABILITY ARE DECREASED.

10. ON THE BASIS OF THE ABOVE GEOLOGIC CONSIDERATIONS, PROF. MARINELLI HAS SELECTED SEVEN AREAS IN GREECE WHICH PRESENT FAVORABLE CONDITIONS FOR FINDING GEOTHERMAL ENERGY. THESE ARE IN DECREASING ORDER OF FAVORABILITY:

1. THE ISLE OF MILOS
2. THE ISLE OF NYSIROS
3. THE ISLE OF LESBOS
4. METHANA PENINSULA IN THE SOUTHERN PART OF GULF OF SARONIKOS
5. SOUSAKI REGION ON NORTH SIDE OF GULF OF SARONIKOS
6. THERMOPYLAE
7. NORTHERN EUBOEIA

11. MILOS - MILOS IS THE ONLY LOCALITY WHERE EXTENSIVE PROSPECTING WORK FOR GEOTHERMAL ENERGY HAS BEEN CARRIED OUT. DETAILED GEOLOGIC MAPPING IS ALMOST COMPLETED, AN ELECTRICAL RESISTIVITY SURVEY HAS BEEN COMPLETED, AND 65 THERMAL GRADIENT HOLES (50 TO 80 M DEEP) HAVE BEEN DRILLED. ONE HOLE 72 M DEEP INTERSECTED STEAM AT 35 M AND HAD TO BE SEALED WITH 20 TONS OF CEMENT TO PREVENT A BLOW OUT.

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12. MESOZIC SEDIMENTS (SILTS, AND SANDS WITH LIMESTONE LENSES) WHICH HAVE BEEN METAMORPHOSED TO GREEN AND BLUE SCHIST FACIES FORM THE BASEMENT ROCKS. MAINLY SILICEOUS VOLCANIC ROCKS (PLIOCENE TO QUATERNARY) WITH ABUNDANT PUMICE FORM THE MAIN PART OF THE ISLAND. THE PUMICE IS ALTERED TO A THICK LAYER OF KAOLINITE AT THE SURFACE AND TO MONTMORILLONITE BENEATH THE KAOLINITE. THE CLAY IS CONSIDERED TO BE AN EXCELLENT IMPERMEABLE CAP ROCK. POSSIBLE RESERVOIR ROCKS BENEATH THE ALTERED PUMICE INCLUDE LENSES OF MARBLE IN THE SCHIST AND A THIN UPPER MIOCENE OR PLIOCENE LIMESTONE THAT MAY EXTEND BENEATH THE VOLCANIC COVER.

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13. HIGH TEMPERATURE WATER IS BELIEVED TO EXIST AT DEPTH BECAUSE OF THE HOT SPRING AND FUMAROLE ACTIVITY AND BECAUSE TWO LARGE PREHISTORIC, BUT RECENTLY OBSERVED, PHREATIC OR HYDROTHERMAL EXPLOSION CRATERS EXIST IN THE CENTRAL PART OF THE ISLAND. THE LARGEST IS ABOUT 1/2 KM IN DIAMETER.

14. A LOW-RESISTIVITY ANOMALY EXISTS BENEATH A VALLEY (BOUNDED BY FAULTS?) IN THE CENTRAL PART OF THE ISLAND, AND COINCIDES WITH A HIGH THERMAL GRADIENT ANOMALY. IN THAT REGION THE COVER OF VOLCANIC ROCKS OVER THE FAULTED BASEMENT OF MESOZOIC METAMORPHIC ROCKS IS THOUGHT TO BE ABOUT 300 TO 500 METERS. STARTING EARLY NEXT YEAR THREE HOLES, RANGING FROM 700 TO 1000 METERS DEEP, WILL BE DRILLED IN THE VALLEY LOOKING FOR HOT WATER AND/OR STEAM IN LIMESTONE (MARBLE) RESERVOIRS WITHIN IMPERMEABLE SCHIST.

15. NYSIROS - ONLY VOLCANIC ROCKS ARE EXPOSED AT NYSIROS. THEIR AGES ARE UNCERTAIN, BUT PROBABLY RANGE FROM PLIOCENE TO RECENT. A HIGH PRIORITY FOR GEOTHERMAL EXPLORATION IS GIVEN TO NYSIROS MAINLY BECAUSE OF LARGE PHREATIC EXPLOSIONS WHICH OCCURRED THERE IN THE LATTER HALF OF THE LAST CENTURY. APPARENTLY NO NEW LAVA WAS ERUPTED AT THE TIME OF THE PHREATIC EXPLOSIONS. A SELF-SEALED CAP ROCK IS THOUGHT TO EXIST AND IT IS HOPED THAT PERMEABLE BURIED VOLCANIC ROCKS WILL PROVIDE AN ADEQUATE RESERVOIR.

16. LESBOS - THE BASEMENT ROCKS AT LESBOS ARE SCHISTS WITH MARBLE LENSES SIMILAR TO MILOS. AN OPHIOLITIC SUITE OF ROCKS WITH PERIDOTITE, SERPENTINE AND CHERTS ALSO IS WELL EXPOSED. THE OLDEST VOLCANIC ROCKS ARE MIOCENE IGNIMBRITES AND THE YOUNGEST ARE PLIOCENE (?) LATITE AND LATITE-ANDESITE FLOWS. WARM SPRINGS (35 DEGREES TO 47 DEGREES C) ARE PRESENT NEAR THE COAST AND HOT SPRINGS (UP TO 87 DEGREES C) OCCUR IN THE CENTRAL- SOUTHERN PART OF THE ISLAND.

17. METHANA - THE PENINSULA OF METHANA IS IN THE SOUTHERN PART OF THE GULF OF SARONIKOS. THICK CRETACEOUS LIME-UNCLASSIFIED

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STONE FORMS THE SOUTHERN PART OF THE PENINSULA. THE MAIN PART OF THE PENINSULA (40 SQUARE KM) IS COMPOSED OF VOLCANIC ROCK. THE VOLCANISM WAS LOCALIZED ALONG AN EW SYSTEM OF FAULTS AND APPARENTLY BEGAN IN THE LATE PLIOCENE OR EARLY QUATERNARY. IT CONTINUED INTO THE 3RD CENTURY B.C., RESULTING IN THE KAMMENO VOUNO VOLCANO. ACID ANDESITES AND DACITES FORM NUMEROUS DOMES, BLOCKY

LAVA FLOWS, AND COARSE EXPLOSIVE PRODUCTS. PUMICE AND FINE-GRAINED PRODUCTS ARE SCARECE.

18. THE HOT SPRINGS IN THE REGION ALL HAVE RELATIVELY LOW TEMPERATURES (MAX. 44 DEGREES C) AND MANY HAVE LARGE RATES OF DISCHARGE. MOST FLOW FROM LAVA, BUT A FEW FLOW FROM LIMESTONE. IT IS POSTULATED THAT HIGH TEMPERATURE FLUIDS ARE LEAKING THROUGH IMPERMEABLE CAP ROCKS AND HEATING THE LOCAL GROUND WATER THAT IS PRESENT ABOVE THE CAP ROCK.

19. OTHER AREAS - THE OTHER AREAS OF INTEREST SELECTED BY PROF. MARINELLI ARE NOT DIRECTLY ASSOCIATED WITH RELATIVELY RECENT VOLCANISM. THE PRESENCE OF WARM SPRING WATERS IS TAKEN AS EVIDENCE FOR HIGHER THAN NORMAL HEAT FLOWS. FAVORABLE GEOLOGIC CONDITIONS OF PERMEABLE RESERVOIR ROCKS (LIMESTONE) AND IMPERMEABLE CAP ROCKS (SCHIST) IN THE VARIOUS REGIONS HAVE LED TO THEIR CLASSIFICATION AS POSSIBLE TARGETS FOR GEOTHERMAL DEVELOPMENT.

20. MANY HOT SPRING AREAS HAVE BEEN RULED OUT FOR PROSPECTING BECAUSE OF A PROBABLE LACK OF PERMEABLE RESERVOIR ROCKS AT DEPTH. OTHER AREAS, SUCH AS SANTORINI ISLAND, HAVE BEEN RULED OUT BECAUSE OF A LACK OF AN ADEQUATE CAP ROCK OVER PERMEABLE ROCKS.

21. THE GREEK EFFORT IN GEOTHERMAL ENERGY HAS ACCOMPLISHED A GREAT DEAL IN THE SHORT 1 1/2 YEARS OF ITS EXISTENCE. THIS IS ESPECIALLY TRUE IN VIEW OF THE SMALL, MAINLY PART-TIME STAFF AND A LIMITED BUDGET. ONLY ABOUT \$84,000 (INCLUDING SALARIES) HAS BEEN SPENT ON EXPLORATION THUS FAR. ABOUT \$35,000 OF THAT MONEY WENT FOR ELECTRICAL RESISTIVITY SURVEYS COVERING 100 SQUARE KMS.

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FUTURE FUNDING WILL DEPEND MAINLY ON THE SUCCESS OR FAILURE OF THE THREE DEEP HOLES THAT WILL BE DRILLED ON MILOS.

22. THE BEST PROSPECTS FOR DEVELOPING GEOTHERMAL ENERGY FOR THE PRODUCTION OF ELECTRICITY IN GREECE APPEARS TO BE ON VOLCANIC ISLANDS IN THE AEGEAN SEA. IT IS PROBABLE THAT THE ELECTRICITY WOULD BE USED FOR NEW INDUSTRIES WHICH WOULD BE MOVED TO THE SOURCE OF POWER.

23. THE GREEK OFFICIALS WOULD LIKE TO BE KEPT INFORMED ABOUT RESULTS OF THE CCMS GEOTHERMAL PROJECT. AT THIS TIME THEIR OWN EXPERIENCE AND CAPABILITY IS SO LIMITED

THAT THEY HAVE NO SUGGESTIONS TO OFFER IN REGARD TO
COOPERATIVE PROJECTS.
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